

Engelmann (G. J.)

THE INTERRUPTED HIGH-VOLTAGE PRIMARY,
OR MIXED CURRENT.

BY

GEORGE J. ENGELMANN, M.D.,
OF ST. LOUIS.



FROM
THE MEDICAL NEWS,
February 3, 1894.

[Reprinted from THE MEDICAL NEWS, February 3, 1894.]

**THE INTERRUPTED HIGH-VOLTAGE PRIMARY,
OR MIXED, CURRENT.**

BY GEORGE J. ENGELMANN, M.D.,
OF ST. LOUIS.

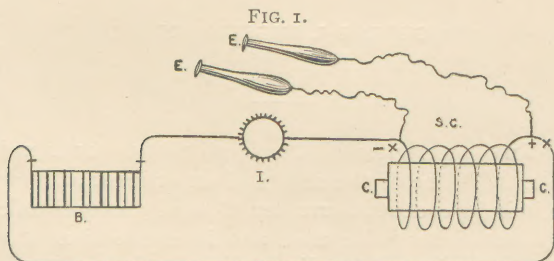
THE interrupted high-voltage primary or mixed current is one of the results of experiment with my new independent interrupter, devised for my faradic apparatus, but to be used also in connection with any galvanic and faradic apparatus; it has proved to possess an individuality peculiar to itself and of great physiologic efficiency, so that I am convinced of its therapeutic value and present it for the consideration of the profession.

This current, which I term the *interrupted high-voltage primary*, or *mixed*, current, is obtained by the interruption of the galvanic flow passing through the secondary coil of the faradic apparatus, and is taken from the terminals of that secondary coil, here used as a primary, which is of higher voltage, of many more winds and greater resistance than the ordinary primary in medical induction-instruments.

The current so obtained is hence not precisely identical with the primary faradic, and may properly be termed a *mixed* current, if not an *interrupted* primary of higher voltage.



A well regulated, controllable interruptor is above all necessary.¹ Any galvanic battery may be used ; one pole is connected with the interruptor, and through this to one of the terminals of the secondary coil of the faradic apparatus² (the binding-post from which the secondary current is taken) ; the



B. Galvanic battery. I. Interrupter. S.C. Secondary coil—X and +X. Terminals of coil. C. Core and primary coil. E. E. Electrodes.

¹ For slow interruption, simple muscle-stimulation and massage, the interrupter ordinarily connected with a complete galvanic apparatus may be used, or, for rapid interruption, a commutator attached to the shaft of a motor, but precision is necessary, and ere long the perfected instrument, which has been devised and constructed by Messrs. Waite & Bartlett in accordance with my suggestions, will be in the hands of the profession, and accurate work, record, and comparison of results will then be possible.

² Not every faradic apparatus will answer, as most instruments have but a single coil and this may give a very unsatisfactory mixed current. To obtain the various therapeutically serviceable phases of this current an induction-apparatus, with a graded set of coils, is necessary ; but if it has but one secondary coil it should be of approximately 1800 W. and 13 ohms R., or of about 800 feet of 22 wire, as this develops the most generally useful form of the interrupted high-voltage current, the painless muscle-permeating current.

other pole of the galvanic battery is connected directly with the remaining terminal of the secondary coil, and with these same two terminals the rheophores carrying the electrodes are connected.

A current so produced combines the characteristics of the galvanic and the induction flow; it has the same galvanometric quantity and the same chemic effect as a simple galvanic current of the same intensity, or, from the same number of cells applied in the same manner *plus* the voltage and the physiologic effects obtained from the winds of the coil; coil and patient being connected in multiple, the resistance is diminished and the current increased, but increased in voltage rather than ampèrage—converted, I may say.

The *physiologic effects are peculiar*, and differ materially from those of any other form of electricity in medical use, the current combining, as it were, the quantity and chemic effect of the galvanic with the voltage of the faradic; the effects resemble most nearly those of the primary faradic, but are more powerful and indicative of greater quantity, most marked in their *action upon muscular fiber*, which is affected by this *as by no other form of electricity*.

A variety of effects are produced by the use of different current-intensities and different coils; yet while this current will undoubtedly be of distinct value in certain nerve-lesions, it will prove pre-eminently a *muscle-current*, as it contracts the muscle most perfectly, acting upon every fiber in the most marked manner, like a powerful interstitial or intercellular massage.

The character and effect of the current depend upon the following elements, which must be noted, as it is by a variation in these factors that the varying therapeutic results are obtained :

1. The number of cells or intensity of the primary battery-flow.

2. The resistance and number of winds of (the secondary) coil.

3. The number of interruptions.

4. The position of the secondary coil in reference to the core and primary.

5. The character and location of the electrodes.

1. The number of cells used or the intensity of the primary battery-flow determines the galvanometric measure and chemic effect ; these being the same as from an ordinary galvanic current without insertion of the coil and applied in the same manner, it is evident that the character of the current must in a measure depend upon this factor ; but as voltage and induction-effects are prominent, the number of cells to be employed is determined, not by the chemic effect to be produced, but by the coil to be used. Only one cell can be employed in connection with a short coil, the number of cells being increased with the resistance and number of winds in the coil ; but more than ten or twelve cells, if in good condition, can hardly be used to good advantage, even with the long fine coils, at least on healthy tissues.

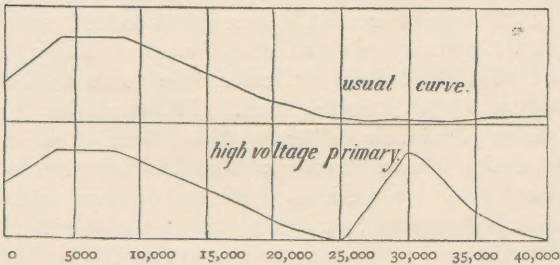
2. It is the coil preëminently which determines the character and effect of the current,¹ the resistance and

¹ In speaking of *the coil*, I invariably refer to the *secondary* coil of the faradic apparatus, in position on the instrument, *used as a primary* in this circuit.

number of winds materially varying its physiologic value, but not in precisely the same manner as when used as a secondary in the faradic current proper. The faradic current from a coil of high voltage, or many winds, has *least* quantity, whilst the mixed current from this coil is of necessity one of *greatest* quantity.

The lower the resistance of the coil and the less the number of winds, the more powerful the induction-effect and the less the quantity of the primary galvanic force to be employed: No. I coil (Engelmann), 0.8 ohms R., 528 winds, has an effect, both motor and sensory, too powerful for therapeutic use, even with one single cell of the weakest Leclanché.

FIG. 2.



No. II, the medium coil, 13 ohms R., 1750 winds, with one cell from any galvanic battery, produces the most satisfactory, deep, muscle-contracting currents, permeating every fiber. This is, *par excellence*, the coil which gives value to the current, and it is remarkable how completely it can be confined to a distinct muscle by the location of the

electrodes ; whilst permeating its fibers it does not seem to radiate beyond.

For the developing of the most satisfactory results, the number of cells used must be increased with the resistance and number of winds in the coil :

	Feet.	Wire.	Winds.	Number of cells found to be effective.
For a coil of	1500	36	4,000	4 to 5
" "	3000	36	7,000	7
" "	4500	36	10,000	9 to 11

By longer coils muscular contractions are likewise produced ; but these are more painful, and the chemic effects of the galvanic current begin to assume prominence ; these should prove efficient for other therapeutic purposes, when more marked galvanic effects are called for.

3. Change of relation between the secondary coil and the primary coil and core, *i.e.*, the moving to and fro of the coil on the scaled slide, varies the intensity of physiologic effect. This variation of intensity is similar to that of the primary faradic, but differs in some features ; if coils of low electro-motor force are used, the intensity of physiologic effect is increased by a sliding out of the coil away from the core ; this is most marked in the coil of fewest winds, coil I, 528 winds ; somewhat less so, but still very decided, in coil II, 1750 winds, 13 ohms R. ; coils of higher E. M. F., longer ; fine-wire coils, on the contrary, *weaken* the current-effect by the drawing out of the coil, or the moving away from the core ; this is true, even of the coil of 1500 feet, or 4000 winds, and of the muscle-coil

of fine wire in multiple, 6500 winds, and only 4 ohms R.

The true primary coil of the apparatus is ignored in these experiments, and its terminals are not connected. When this is done it acts as a damper, like the copper tube of Duchesne, to weaken the current.

4. The number of interruptions, or the rates of vibration, control the physiologic effect of this current, as they do that of the faradic, whilst the chemic and galvanometric action is affected but little and that in a contrary sense.

Interruption and alternation affect the physiologic action of this current in the same manner, but I shall speak only of interruption, pure and simple, as it is the interrupted primary which will prove of greatest therapeutic value, this being more agreeable, less painful and harsh than the alternating, and equally, if not more, efficacious as a muscle-contractor, so that the alternating primary will only be used when it is of importance that all chemic action be avoided. Both currents, interrupted and alternating, will respond to certain therapeutic indications; but as a simple muscle-contractor the more irritating and disagreeable alternating will find little favor as compared with the interrupted current; both, however, respond in precisely the same way, as regards physiologic effect, to variation in the rate of interruption.

Other conditions being equal, the same number of interruptions and alternations produce the same effect, *i. e.*, 10,000 interruptions have the same comparative effect as 20,000 alternations upon the cur-

rent. As in the secondary faradic, the effect of the current increases with the rapidity of interruption from 1 to 2500 or 3000 per minute, and, after attaining a maximum effect, decreases with increased rapidity of interruption until a rapidity is reached with which all sensation ceases. Though the galvanometric effect is unchanged, the chemic effect increases; the more intense the current the greater the number of interruptions necessary to completely annul its effect.

Coil I, heavy, with one cell, causes powerful and painful contractions, too violent for general use with the ordinary rate of interruption; yet it ceases to have any effect, or to be felt, with 14,000 interruptions per minute (this when full in, over core, with small sponge electrodes to upper and lower arm, the effect depending greatly upon the moisture of the electrodes and the pressure upon them).

The 10,000-wind coil, 4500 feet of 36 wire, 11 cells, sponge electrodes to upper and lower arms, ceases to be felt at 25,000, whilst if only 7 cells are used, the same result is accomplished by 20,000 interruptions per minute.

The general law mentioned, of increase of effect with increase in rapidity of interruption, then decrease with still greater rapidity, holds good with one curious exception, true of the secondary faradic, as it is of the interrupted, or alternating high-voltage primary; and this interesting phenomenon, which merits a more thorough discussion elsewhere, I must here at least note: it is that currents from certain coils, as far as I have observed, from 5000 to 10,000 winds, 36 wire, under certain conditions,

after passing that rapidity of interruption at which they cease to be felt, *reappear* with greater rapidity, again *attain the previous maximum*, to again lose all effect with still greater frequency of interruption. In place of the simple rise and fall, there is a second shorter and additional curve of rapid rise to the previous maximum and fall to zero.

The 36-wire coil of 10,000 winds, with 11-cell primary galvanic force, ceases to be felt with 25,000 interruptions, then reappears, regains its previous efficiency at 30,000, and again weakens as the interruptions grow more rapid, to completely fade away as they attain a speed of 40,000 per minute; if fewer cells are used with the same coil, precisely the same phenomenon is observed, the same effects being produced by lower rates of interruption as the current is weaker.

5. That the character of the electrode, which determines penetration and surface-resistance, influences this current, as it does both galvanic and faradic, need hardly be mentioned; material, size, degree of moisture, location, and pressure upon the electrode, all serve to vary the sensation and effect of the current, and must be considered as determining factors.

This interrupted, high-voltage primary current possesses an individuality which must secure it a distinct place as a therapeutic agent; by blending the quantity and chemic action of the galvanic with the voltage and mechanical effects of the faradic we are enabled to produce peculiar effects; yet both are so modified that the resultant differs from a simple combination of these two forms of elec-

tricity. It differs from the painful interrupted or alternating galvanic as it does from the ordinary faradic, the secondary or induced current, and it will be resorted to when deep, penetrating effects are desired and when permeating muscle-currents are indicated ; it will act, I believe, in those cases in which faradization fails. No other current, with such penetrating power, can be so localized and grasp every fiber of a muscle as does this.

Therapeutic effects I have not, as yet, been able to test, and cannot speak of its action upon muscle in central and peripheral lesions, but physiologic experiment indicates the powerful influence of this current, from proper coils, upon contractile tissue, and it is in this direction that investigation must first proceed.

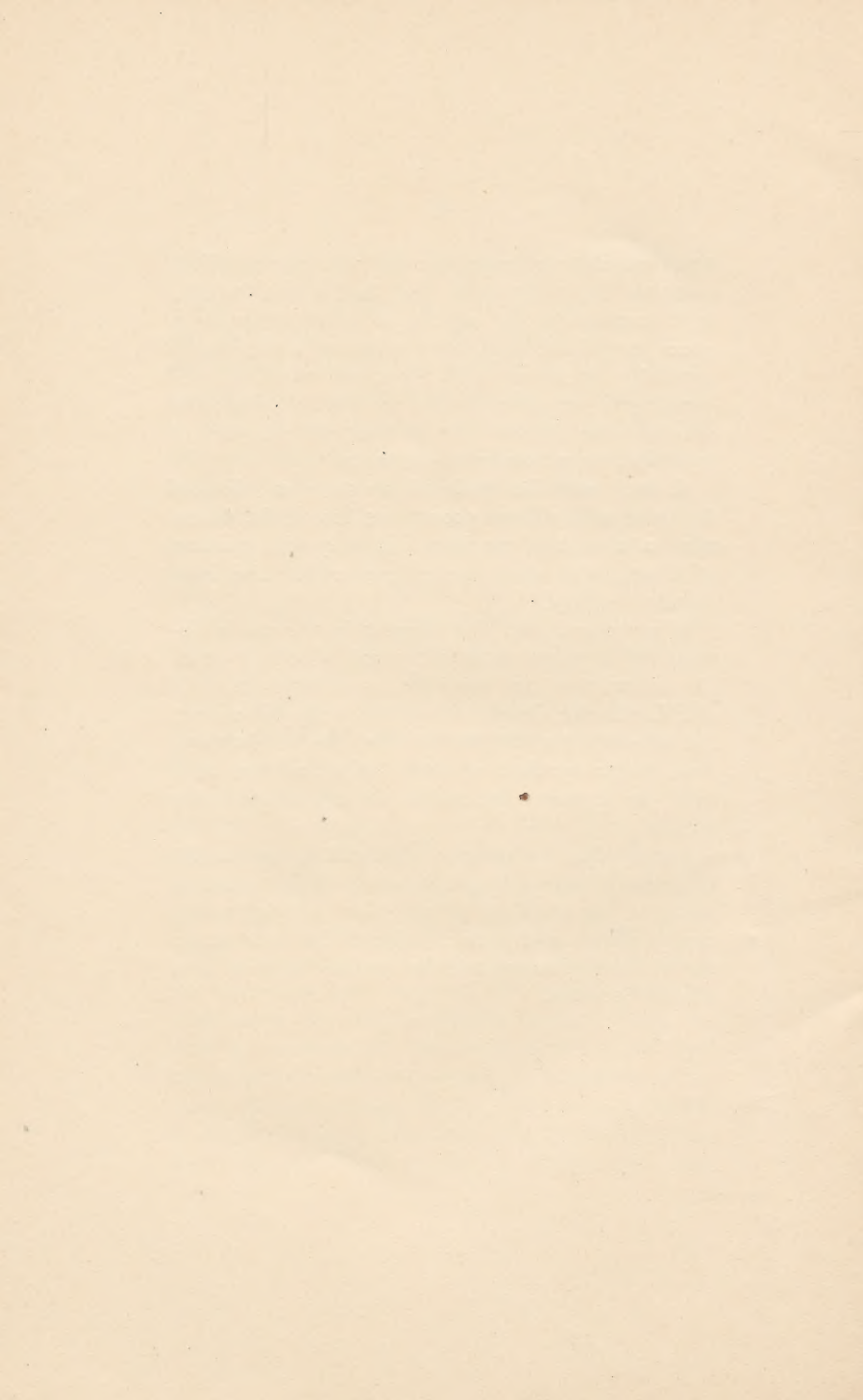
In conclusion, a word of caution to the operator: Care must be exercised in the selection of battery-force and coils until a knowledge of the current and its effects is obtained. It is best to begin with the use of the lowest current-intensities, or the fewest galvanic cells which will take effect through the coil employed, or to use the number of cells here indicated as suitable for the various coils, varying the current by the pushing in or out of the coil, as the case may demand ; when familiarity with the current has been acquired, this may be varied by variation in the galvanic flow for certain effects. It must be remembered that coils of low E. M. F., heavy coils of few winds, must be *drawn out* to *increase* the physiologic effect, whilst coils of higher E. M. F., the long, fine coils, vary less and in a different manner ; these *weaken* by *drawing out*. It is

also important to remember that the current-effect increases more distinctly than that of the faradic, with increase in the rapidity of interruption up to 3000 per minute, and, after attaining a maximum, gradually decreases with increased rapidity, decreasing in proportion to the current-intensity; the stronger the current the greater the number of interruptions necessary to reduce it.

A note must be made of the peculiar effect of fine-wire coils of from 5000 to 10,000 winds, which again attain a brief maximum intensity with increase of interruption after having been obliterated by a certain rapidity.

It is evident that this current is one easily obtained if a proper interrupter and a coil of suitable construction are available, as a single galvanic cell, Leclanché, Gonda, dry or red acid, will answer for use with the muscle-coil, the galvanic battery, or a larger number of cells, being needed only with the longer coils, which are not as generally useful.

I trust that an earnest trial will be given the interrupted high-voltage primary, which merits a place in our therapy, if only for its permeating muscle-effects, and I am convinced that therapeutic use will soon demonstrate the greater range of this efficient current.



The Medical News.

Established in 1843.

A WEEKLY MEDICAL NEWSPAPER.

Subscription, \$4.00 per Annum.

The American Journal

OF THE

Medical Sciences.

Established in 1820.

A MONTHLY MEDICAL MAGAZINE.

Subscription, \$4.00 per Annum.

COMMUTATION RATE, \$7.50 PER ANNUM.

*LEA BROTHERS & CO.
PHILADELPHIA.*